

Ground and Airborne Methane Measurements using Optical Parametric Amplifiers

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We report on an initial airborne demonstration of atmospheric methane column measurements at 1.65 μm using a widely tunable, seeded optical parametric amplifier (OPA) lidar and a photon counting detector. Methane is an important greenhouse gas and accurate knowledge of its sources and sinks is needed for climate modeling. Our lidar system uses 20 pulses at increasing wavelengths and integrated path differential absorption (IPDA) to map a methane line at 1650.9nm. The wavelengths are generated by using a Nd:YAG pump laser at 1064.5 nm and distributed feedback diode laser at 1650.9 nm and a periodically-poled lithium niobate (PPLN) crystal. The pulse width was 3 ns and the pulse repetition rate was 6.28 KHz. The outgoing energy was approximately 13 $\mu\text{J/pulse}$. A commercial 20 nm diameter fiber-coupled telescope with a photon counting detector operated in analog mode with a 0.8 nm bandpass filter was used as the lidar receiver. The lidar system was integrated on NASA's DC-8 flying laboratory, based at Dryden Airborne operations Facility (DAOF) in Palmdale CA. Three flights were performed in the central valley of California. Each flight lasted about 2.5 hours and it consisted of several flight segments at constant altitudes at approximately 3, 4.5, 6, 7.6, 9.1, 10.6 km (10, 15, 20, 25, 30, 35 kft). An in-situ cavity ring down spectrometer made by Picarro Inc. was flown along with the lidar instrument provided us with the "truth" i.e. the local CH_4 , CO_2 and H_2O concentrations at the constant flight altitude segments. Using the aircraft's altitude, GPS, and meteorological data we calculated the theoretical differential optical depth of the methane absorption at increasing altitudes. Our results showed good agreement between the experimentally derived optical depth measurements from the lidar instrument and theoretical calculations as the flight altitude was increased from 3 to 10.6 km, assuming a constant methane mixing ratio of 1.8 ppm.

The in-situ spectrometer did not show any significant deviations from the ambient concentrations. Further analysis using meteorological data from the Global Modeling and Assimilation Office (<http://gmao.gsfc.nasa.gov/>) to derive the theoretical optical depth also showed good agreement with the experimentally derived values.

The OPA lidar system with slight modifications has also been used to measure CO₂, water vapor, and CO in the near and mid-infrared spectral regions on the ground.